

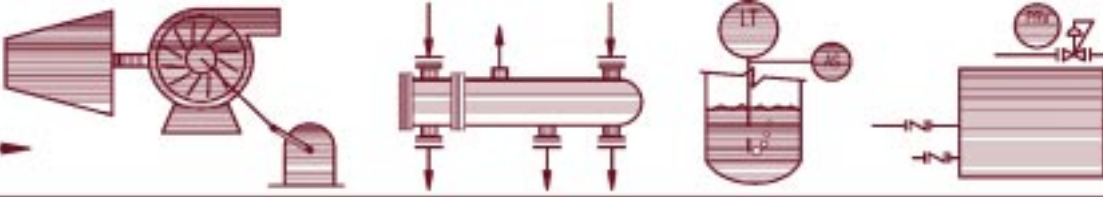
# **ENERGY SOURCE**

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for Industrial Steam and Power Users

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## A Case Study: Results of Upgrades to Existing Wood-Fired Boilers at Jack Daniel Distillery

By: *William G. Spraggins, Manager of Engineering, Jack Daniel Distillery*  
*Douglas W. Kindred, Vice President of Project Operations, ESI*

If you get the chance to spend some time in quaint Lynchburg, Tennessee, make sure that you take the tour of Jack Daniel Distillery. Since it is a dry county, the only sample you will get is lemonade at the conclusion of the tour, but the tour itself is very interesting.

One thing that you will learn is that Jack Daniel is very environmentally conscious. Two wood-fired boilers were installed in 1979 to utilize wood waste from the surrounding area to generate their process steam.

The wood-fired boilers are Keeler units equipped with Detroit Rotograte traveling grate stokers. The steaming capacities of the boilers are 55,000 pph and 85,000 pph at an operating pressure of 185 psig at saturated steam conditions. The units originally burned coal and wood, but the coal feed system has been removed.

The original wood feeding system consisted of an oscillating swing spout arrangement at the discharge of a belt conveyor feeding each boiler. The spouts directed the wood waste to each of the three Detroit windswept spouts on the larger boiler and one of two spouts on the smaller boiler. The belts were fed wood waste from a live bottom silo.

### Problem Areas

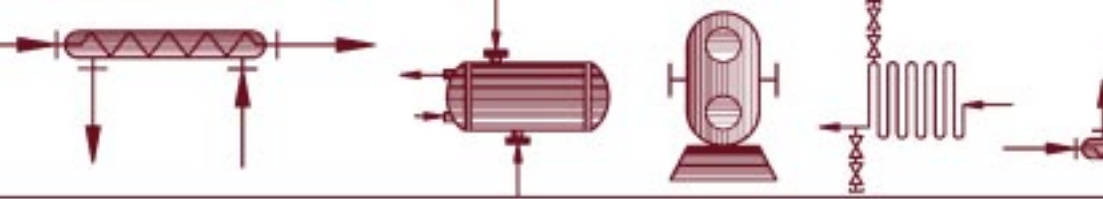
Prior to the upgrades that were installed by ESI in the fall of 1997, the installation experienced the following problems:

- Poor distribution of fuel across the grates with large bare spots across the front and large piles in the middle.
- Low furnace temperatures due to large amounts of tramp air entering through the swing spouts and the bare spots on the grate.
- Carryover of large portions of unburned char into the boiler outlet hoppers and into the baghouse.
- Pluggage of the boiler outlet hoppers due to excess carryover.
- Lower boiler efficiency due to tramp air and high levels of unburned carbon in the ash.
- Poor response to load swings that often required operation of auxiliary natural gas burners to maintain pressure.
- Variations in plant header pressure due to poor load swinging capabilities.
- Interruptions to the wood supply due to pluggage in the silo or swinging spout assembly. This also required operation of the gas burners to satisfy plant steam loads during these upsets.

### The Modifications

Bill Spraggins, Manager of Engineering for Jack Daniel, recognized that the fuel distribution problems needed to be resolved. Bill had previously lowered the windswept spouts in one of the boilers when the coal feeders were abandoned in 1993. The positive impact of this relatively minor modification convinced him that further work in this area should be fruitful. ESI was asked to provide recommendations and a price for a new state-of-the-art wood feed system and was awarded the contract.

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The modifications included the following:

- New, wider Detroit windswept spouts were installed lower in the furnace. The lower elevation provided excellent front-to-rear distribution of fuel and the wider spouts eliminated the bare spots between windswept spouts.
- Each windswept spout was fed with its own variable pitch twin screw feeder with surge bin. These are ESI's own design with extensive design provisions to minimize bridging. The surge bins also provide an air seal to eliminate tramp air from being sucked into the furnace. Vector type variable frequency drives were installed to provide very accurate speed control and repeatability of the twin screw feeders. The screws were fabricated of stainless steel for long life and resistance to corrosion from the tannic acid present in the wood. Individual twin screw feeders for each windswept spout provide superior repeatability of fuel flow as compared to a common surge bin that feeds multiple windswept spouts.
- A recirculating fuel loop was installed that consisted of two new belt conveyors and a heavy-duty distribution drag chain to keep all surge bins full. The drag chain feeds the two surge bins for the small boiler as well as the three surge bins for the larger boiler. A small amount of excess fuel is recirculated back to the fuel house.
- The control system was modified by Jack Daniel to enable the capabilities of the new system to be realized.

## The Results

The modifications were very successful. The load response of the boilers was drastically improved and full automatic control of the boilers with stable header pressures is now readily achieved on wood alone.

The fuel distribution across the grate was dramatically improved and bare spots on the grate were essentially eliminated. Once the fuel distribution problems were solved, the units were able to operate at lower excess air levels. This reduced the velocity of the flue gas inside the furnace and allowed more time for the particles to burn.

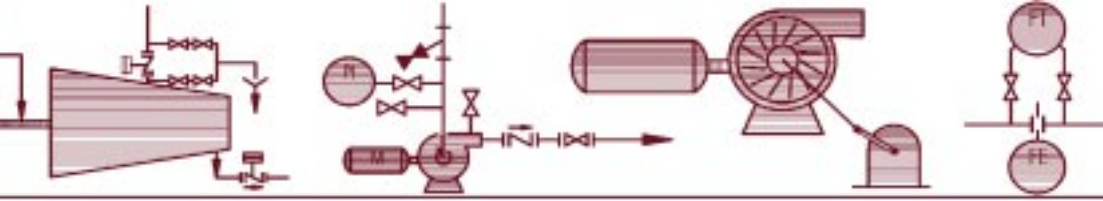
Carryover of unburned char was significantly reduced and pluggage of the boiler outlet hoppers was eliminated. Tests performed by Jack Daniel revealed that the BTU value of the flyash dropped considerably.

- Natural gas usage has decreased significantly
- A more stable boiler has produced increased efficiencies.

In the 15 months that the boilers have operated since the modifications were made, the Jack Daniel installation has yet to suffer a single bridging incident in any of the five twin screw feeders. The key to this performance is twofold; the first is the design of the twin screw feeders and the second is that the fuel is properly hogged to a minus 2" product size.

This sizing is important for proper feeder operation as well as optimized combustion on the grate. The larger the fuel particle, the longer it takes the moisture to be removed. This fuel sizing is the standard specified by Detroit Stoker and other major stoker manufacturers. If you operate a wood-fired facility and have bridging problems, proper fuel sizing is a key area to investigate. Bridging will occur even with proper fuel sizing if the feeders are not properly designed.

In conclusion, the laws that govern the operation of a boiler plant are basic physics. It is always rewarding to see the expected benefits that theory predicts realized in "real world" solutions. The dramatic improvements noted at Jack Daniel were all due to the application of these basic principals. The problems

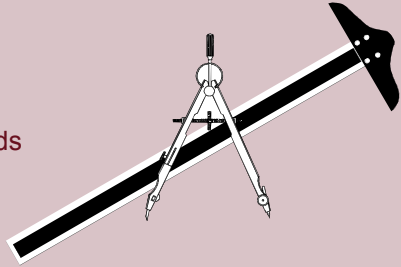


experienced at Jack Daniel are quite common for wood-fired boilers of this era. In many cases, modifications to an older boiler plant can provide a significant improvement at a fraction of the cost of a new plant. ESI builds new power plants as well as performing upgrades to existing facilities. Please feel free to contact ESI for further details if you feel that we may be of help.

Oh, and one more thing, plan your trip to Lynchburg in advance and be sure and make reservations to eat at Miss Bobo's where the family style food is excellent.

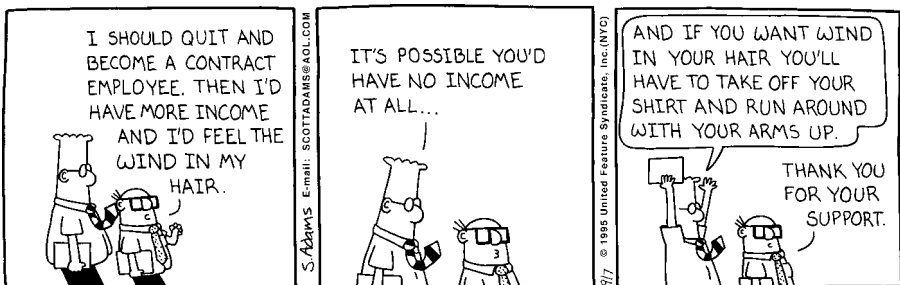
## DESIGN TIPS

The success of any steam and power installation is the integration of hundreds of subtle design features that ensure everything operates satisfactorily.

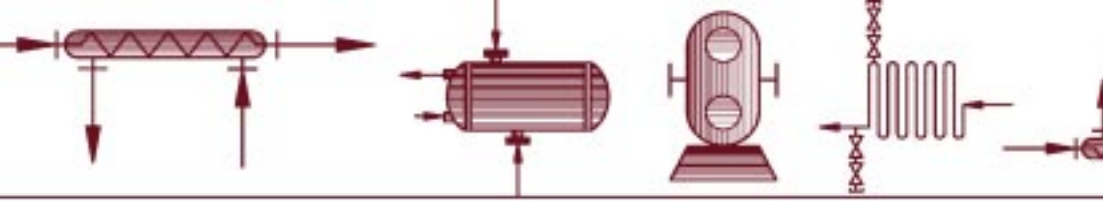


Following are a few design tips:

- When designing a boiler system in which two steam drum safety relief valves will protect a single boiler, the smaller valve must be designed with the capacity to relieve at least 50% of the flow of the larger valve.
- In piping system design, consideration must be given to the fact that when performing a hydrostatic test on a piping system, the maximum hydrostatic test pressure against a "closed" valve is only 1.1 times the design pressure of the valve, not 1.5 times the design pressure. Therefore, valves must be selected so that 1.1 times their design pressure is within 1.5 times the piping system design pressure.
- When installing pumps which operate at elevated temperatures, provisions must be made for the proper warm-up of the pumps. This could be accomplished by a simple bypass around the pump discharge check valve thereby allowing the on-line pump to back feed through the bypassed pump until the bypassed pump is warm, or by providing drain valves on both the pump suction and discharge lines which can be carefully opened to allow flow to drain until the pump is warm.
- Bypass valves around boiler feedwater control stations should incorporate an additional small "high pressure" warm-up valve for times when the boiler will be filled using the boiler feedwater pumps, but there is no pressure on the boiler. During these times, the high differential pressure across either the control valve or the full size bypass valve can cut the valve seats and cause leakage and control problems.



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## “How to Kill a Boiler” Preventive Measures

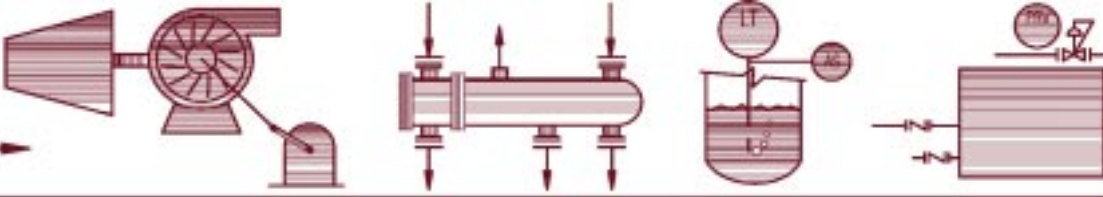
*By: William L. Reeves, P.E., President, ESI*

In conclusion to our series, some common practices that should be followed in order to avoid “Killing The Boiler” include:

- Frequent observation of the burner flame to identify combustion problems early.
- Investigate the cause of any trip before numerous attempts to relight.
- Before lighting a boiler, always purge the furnace thoroughly. This is particularly important if oil has spilled into the furnace. The purge will evacuate the inventory of unburned gases until the concentration is below the explosive limits. If in doubt, purge, purge, purge!
- Verify that the water treatment system is operating properly, producing boiler feedwater of sufficiently high quality for the temperatures and pressures involved. Although zero hardness is always an absolute criteria, other water quality standards based on operating pressures and temperatures as recommended by ABMA should be followed. Never use untreated water in a boiler.
- Blowdown all the dead legs of the low water trips, water column, etc., on a regular basis to prevent sludge build-up in these areas which leads to device malfunction. Never under any circumstance disable a low water trip.
- Verify that the water leaving the deaerator is free of oxygen, that the deaerator is operated at the proper pressure, and that the storage tank water is at saturation temperature. A continuous vent from the deaerator is necessary to allow the discharge of non-condensable gases.
- Continuously monitor the quality of condensate coming back from the process to enable the diversion of the condensate in the event of a catastrophic process equipment failure.
- Adjust continuous blowdown to maintain conductivity of the boiler water within required operating limits and operate the mud drum blowdown on a regular basis (consult your water treatment specialist). Never blowdown a furnace wall header while the boiler is operating.
- The boiler waterside should be inspected on a regular basis. If there are any signs of scaling or buildup of solids on the tubes, water treatment adjustments should be made and the boiler should be mechanically or chemically cleaned.
- The deaerator internals should be inspected on a regular basis for corrosion. This is an important safety issue because a deaerator can rupture from corrosion damage. All the water in the deaerator will immediately flash to steam in the event of a rupture, filling the boiler room with deadly steam.
- The boiler’s warm-up curve should be strictly followed. The standard warm-up curve for a typical boiler is not to increase the boiler water temperature over 100°F per hour. It is not unusual for a continuous minimum fire to exceed this maximum warm-up rate. Consequently, during start-up, the burner must be intermittently fired to ensure that this rate is not exceeded.

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- Make sure that all personnel that work on boilers understand that the thin tubes are quite fragile. Encourage workers to admit any accidental damage so that it can be inspected and/or repaired as necessary.
- If production demands necessitate overfiring of the boiler, make periodic assessments of potential effects of overfiring and communicate these to management.
- When a boiler is shut down for an extended period of time, a nitrogen blanket system should be used to prevent the introduction of air and oxygen into the boiler during cooling and storage, and sodium sulfite should be injected to react with any free oxygen in the boiler water. When a boiler is stored dry, desiccant should be placed in the boiler drums along with the nitrogen blanket to absorb any free moisture.
- Always ensure that the steam drum vent valve is opened whenever the boiler pressure is less than 5 psig.

Well, we hope you have enjoyed our “How to Kill a Boiler” series. If you have just started receiving the *ENERGY SOURCE*, the following topics were covered during this series:

- Part 1. Fuel Explosions (Summer 1996 Issue)
- Part 2. Low Water Conditions (Fall 1996 Issue)
- Part 3. Poor Water Treatment (Winter 1997 Issue)
- Part 4. Improper Warm-Up (Spring 1997 Issue)
- Part 5. Impact Damage to Tubes (Summer 1997 Issue)
- Part 6. Severe Overfiring (Fall 1997 Issue)
- Part 7. Contaminated Feedwater (Winter 1998 Issue)
- Part 8. Improper Blowdown of Headers (Spring 1998 Issue)
- Part 9. Improper Storage (Summer 1998 Issue)
- Part 10. Flame Impingement & Pulling a Vacuum (Fall 1998 Issue)
- Preventive Measures (Winter 1999 Issue)

All of the past issues of the *ENERGY SOURCE* can be found on-line at [www.esitenn.com](http://www.esitenn.com). Once you are on the home page, click Newsletter on the tool bar. You can view the current newsletter or click on archives to view a list of all the past newsletters. If you have any difficulty, feel free to e-mail us at [energysource@esitenn.com](mailto:energysource@esitenn.com).

Now that the “How to Kill a Boiler” series has concluded, the Question is:

**What are we going to write about?**

If you have suggestions about future articles or technical questions you would like addressed in future issues of the *ENERGY SOURCE* - we would like to hear from you. Please e-mail your suggestions or technical questions to [energysource@esitenn.com](mailto:energysource@esitenn.com).